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Kato et al.

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(54) **COMBUSTOR NOZZLE ASSEMBLY, COMBUSTOR EQUIPPED WITH THE SAME, AND GAS TURBINE**

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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,409,791	A *	10/1983	Jourdain et al.	60/240
6,755,024	B1 *	6/2004	Mao et al.	60/776
6,761,035	B1 *	7/2004	Mueller	60/800
7,290,394	B2 *	11/2007	Lehtinen	60/800
7,827,795	B2 *	11/2010	Hicks et al.	60/728

(Continued)

FOREIGN PATENT DOCUMENTS

CN	101354141	A	1/2009
CN	101784841	A	7/2010

(Continued)

OTHER PUBLICATIONS

International Search Report of PCT/JP2013/056870, date of mailing May 14, 2013.

(Continued)

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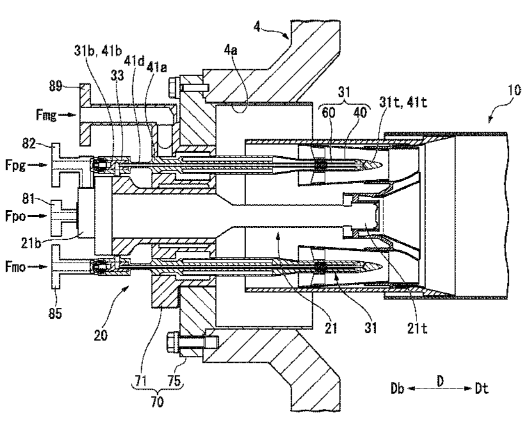
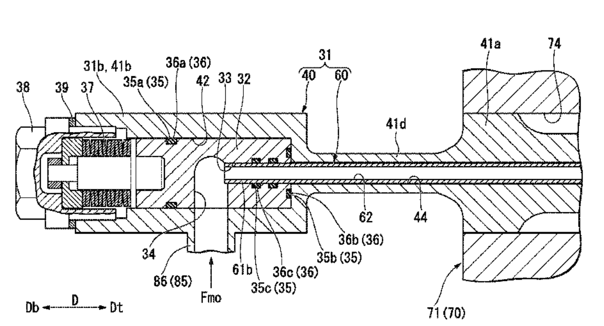
(57) **ABSTRACT**

A combustor nozzle assembly includes: a nozzle mounting base which blocks a combustor insertion opening formed in a turbine casing; a nozzle rod which passes through the nozzle mounting base and has a rod tip portion and a rod base end portion; an oil fuel pipe which is as a whole inserted into the nozzle rod, which has a pipe tip portion and a pipe base end portion, in which fuel is supplied to the inside through the rod base end portion, and which injects the fuel from the pipe tip portion through the rod tip portion; and an O-ring which is disposed in the rod base end portion and suppresses leakage of fuel to the pipe tip portion side between the inner periphery side of the nozzle rod and the outer periphery side of the oil fuel pipe.

6 Claims, 7 Drawing Sheets





(56) **References Cited**

U.S. PATENT DOCUMENTS

7,832,377	B2 *	11/2010	Lee et al.	123/470
2004/0129001	A1 *	7/2004	Lehtinen	60/740
2007/0137218	A1 *	6/2007	Prociw et al.	60/796
2007/0151255	A1 *	7/2007	Johnson et al.	60/776
2009/0223225	A1 *	9/2009	Kraemer et al.	60/723
2009/0277176	A1 *	11/2009	Caples	60/737
2011/0089267	A1 *	4/2011	Stoia et al.	239/589

FOREIGN PATENT DOCUMENTS

CN	102297429	A	12/2011
JP	6-34135	A	2/1994
JP	10-26352	A	1/1998
JP	2003-106528	A	4/2003
JP	3861035	B2	12/2006
JP	2008-190402	A	8/2008
JP	2009-52513	A	3/2009
JP	2009-52859	A	3/2009
JP	2011-085385	A	4/2011

OTHER PUBLICATIONS

Written Opinion of PCT/JP2013/056870, date of mailing May 14, 2013.

Office Action dated Aug. 3, 2015, issued in counterpart Chinese Application No. 201380039058.0, with English translation. (10 pages).

A Notice of Allowance dated Apr. 5, 2016, issued in counterpart Japanese Patent Application No. 2012-168535, with English translation. (6 pages).

* cited by examiner

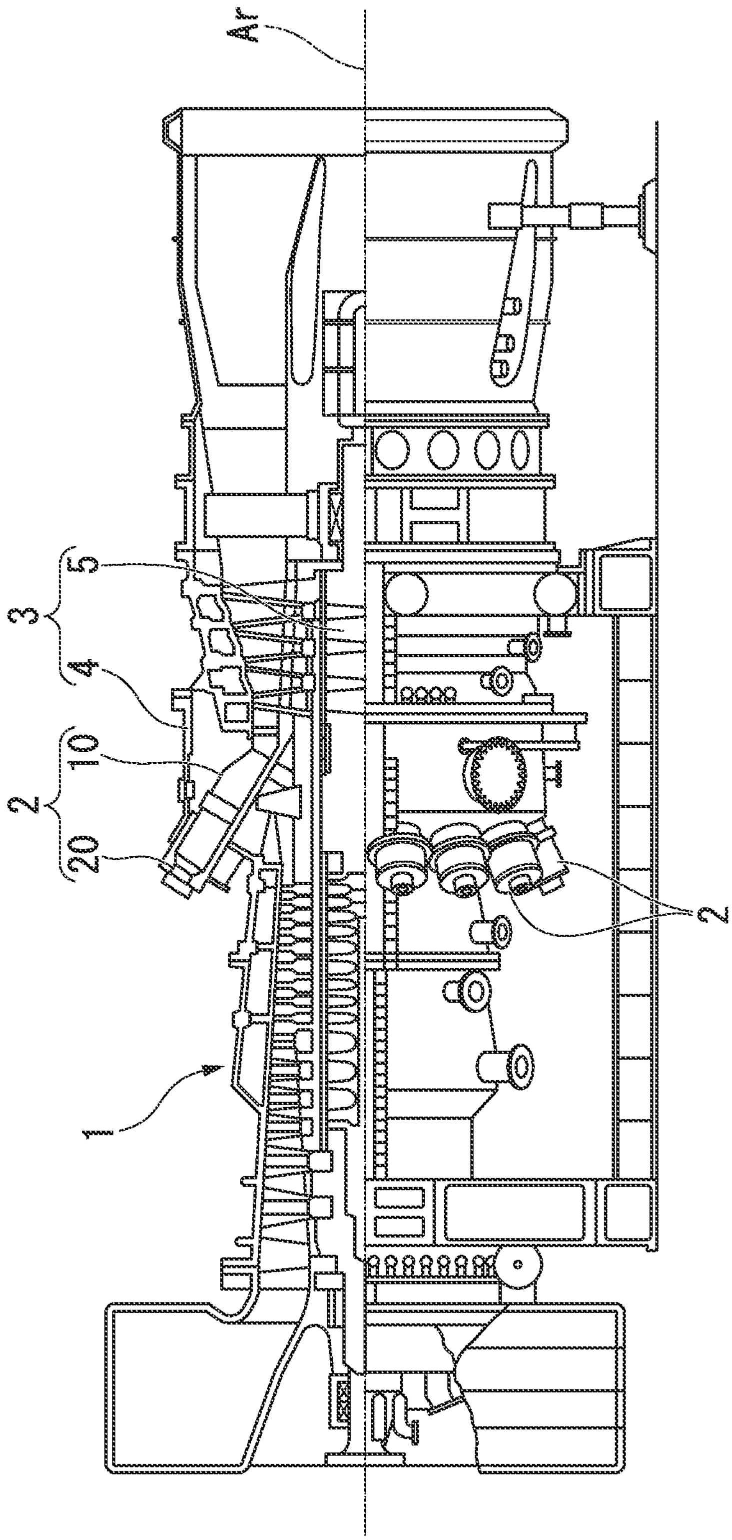
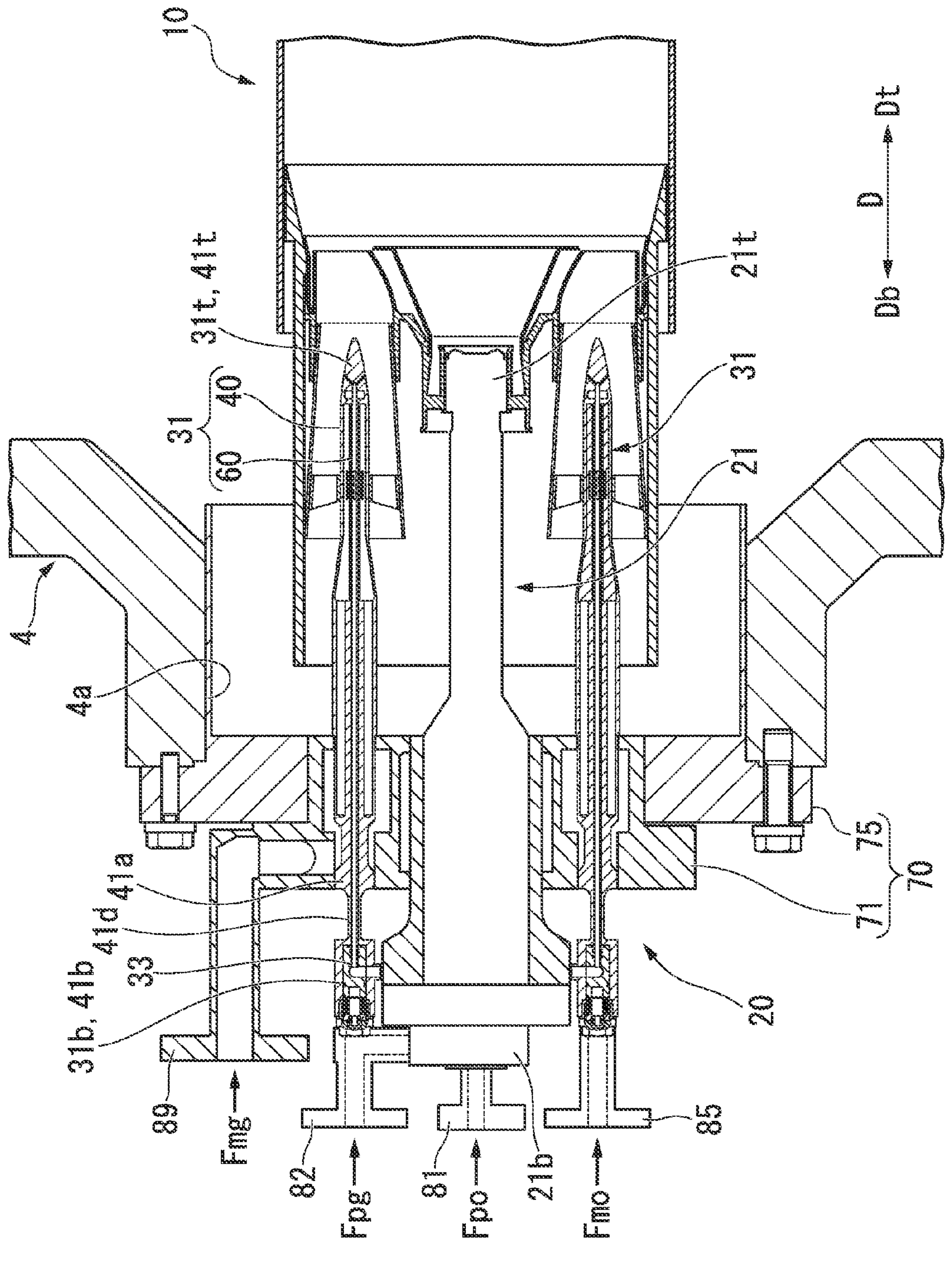


FIG. 1

FIG. 2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Db
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Dt
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70
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31b, 41b
20
89
Fmg
82
Fpg
81
Fpo
21b
Fmo
85

FIG. 3

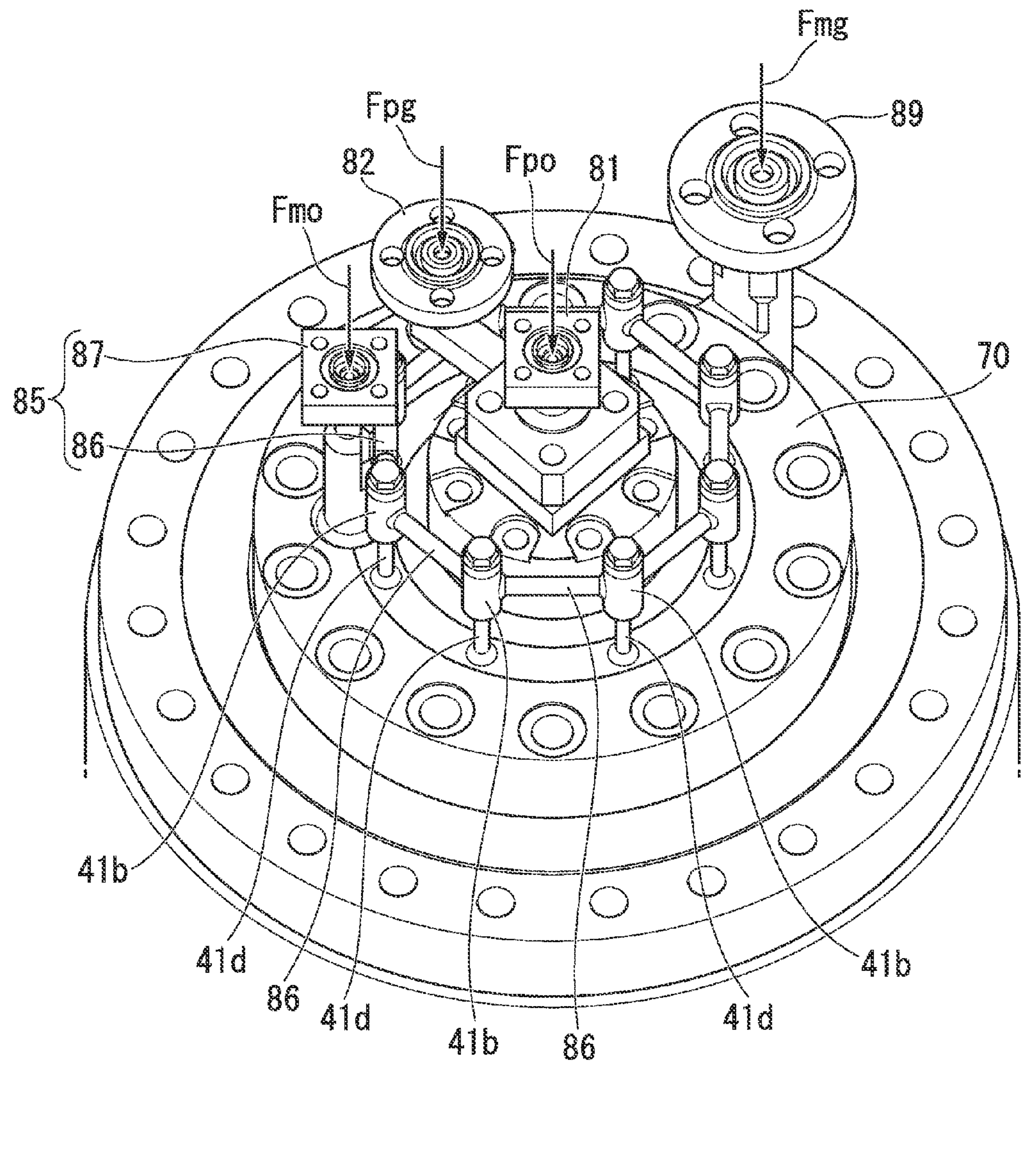
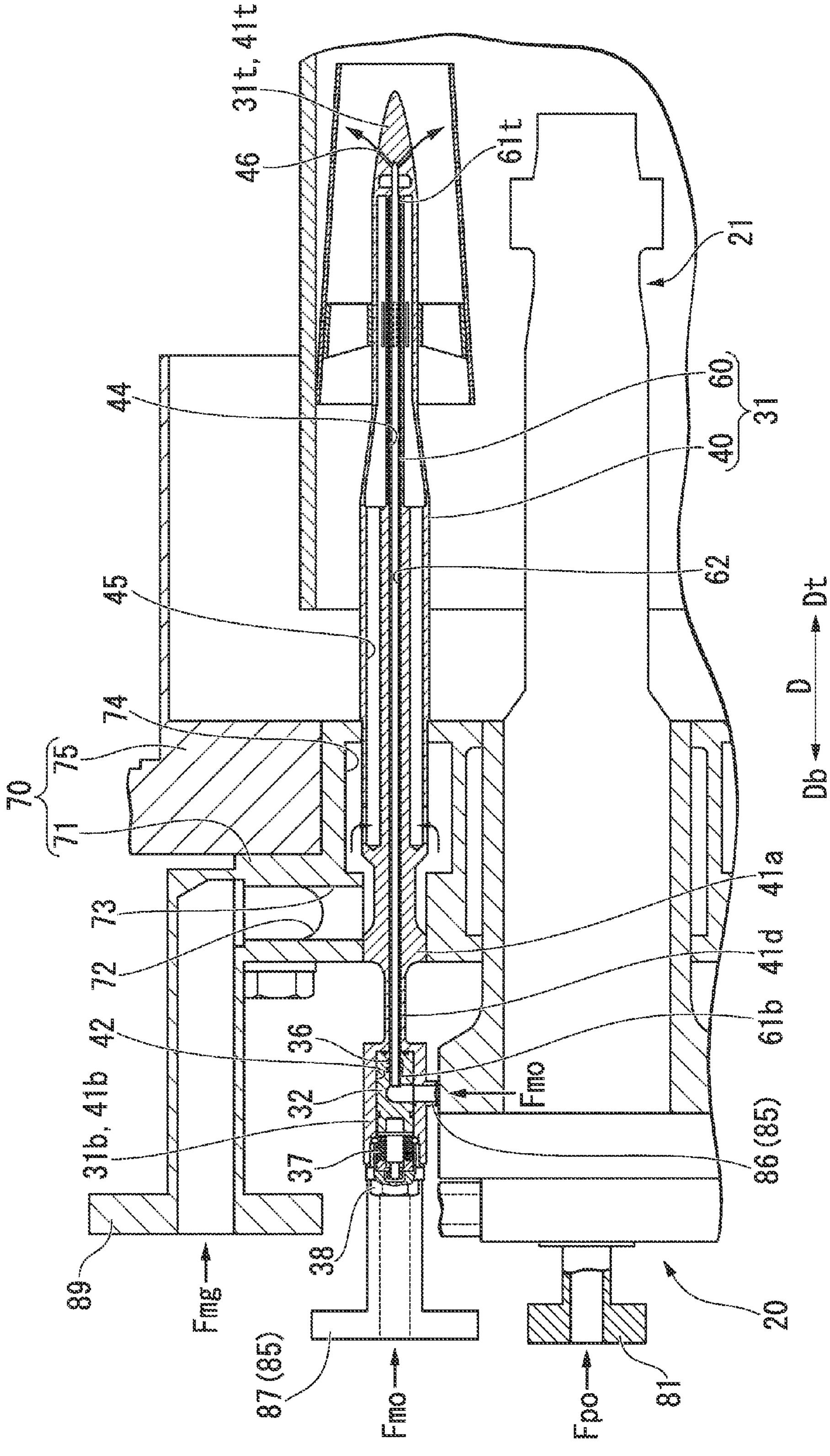


FIG. 4


31t, 41t
46
61t
21
44
60
40
31
62
45
D
Db
Dt
74
75
70
71
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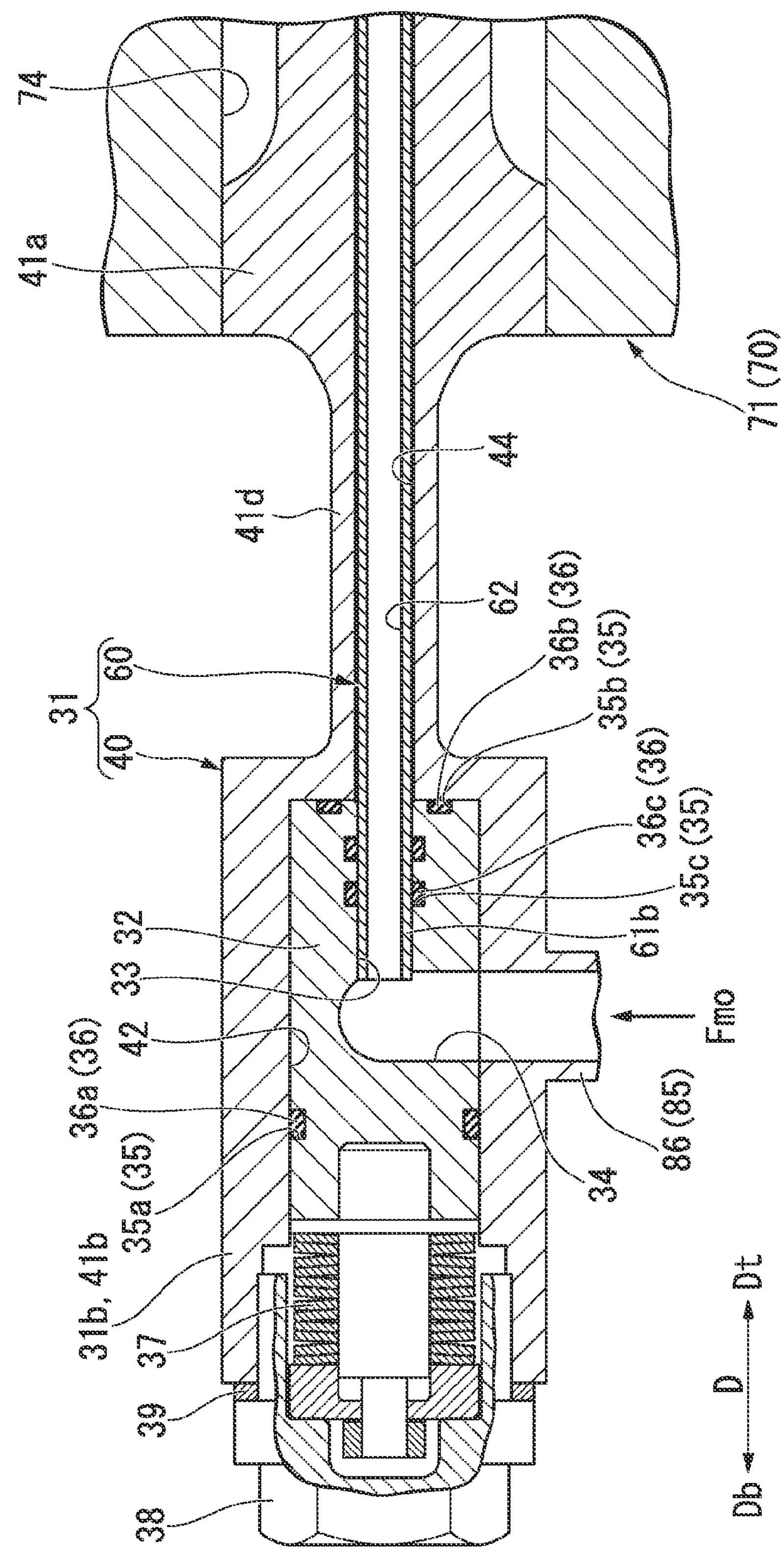
73
72
41d
42
36
61b
Fmo
31b, 41b
32
86 (85)
37
38
89
Fmg
87 (85)
Fmo
Fpo
81
20


74
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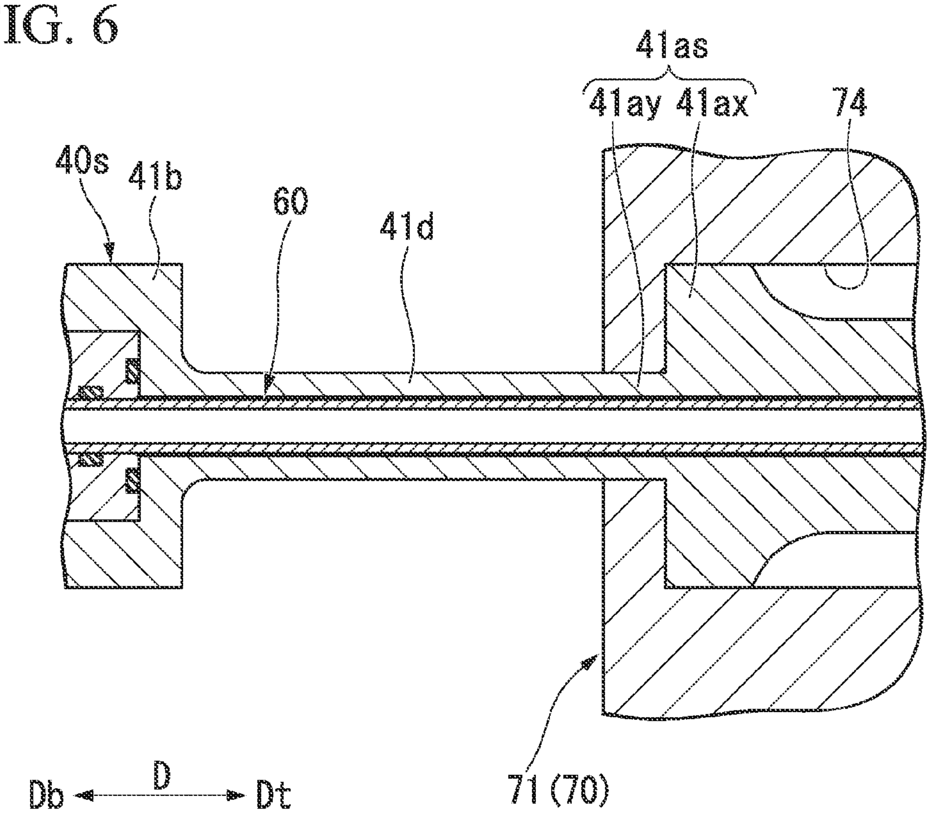
71 (70)
44
41d
62
31
60
40
36b (36)
35b (35)
36c (36)
35c (35)
61b
32
33
42
Fmo
36a (36)
35a (35)
86 (85)
34
31b, 41b
37
39
38
D
Db
Dt

FIG. 5

FIG. 6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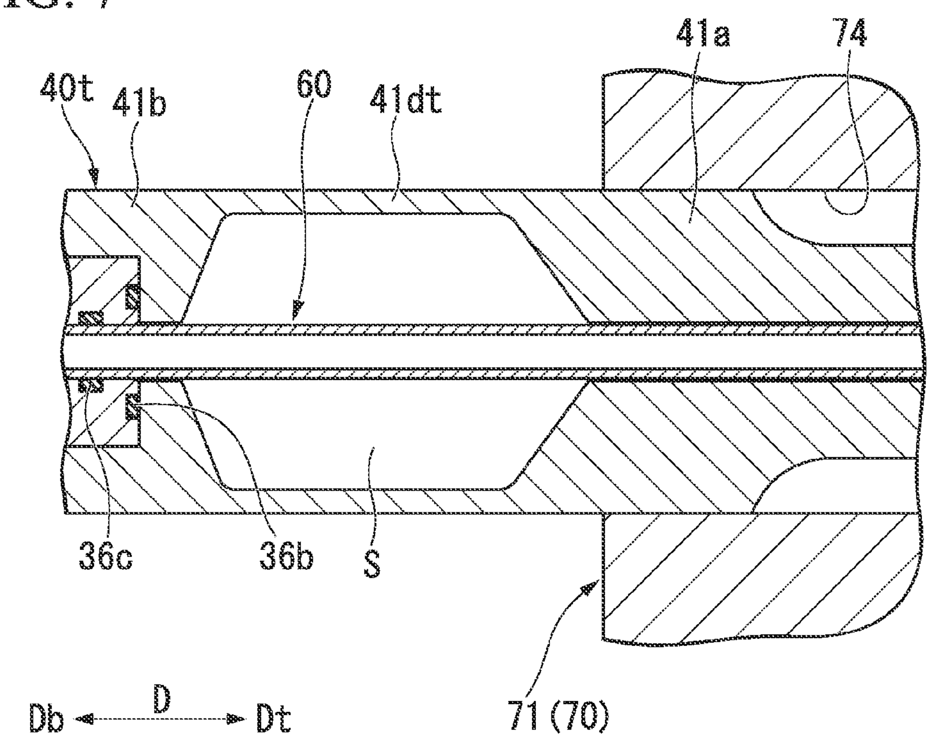
41ay
41ax
74
40s
41b
60
41d
Db
D
Dt
71(70)

FIG. 7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41dt
36c
36b
S
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D
Dt
71(70)

FIG. 8

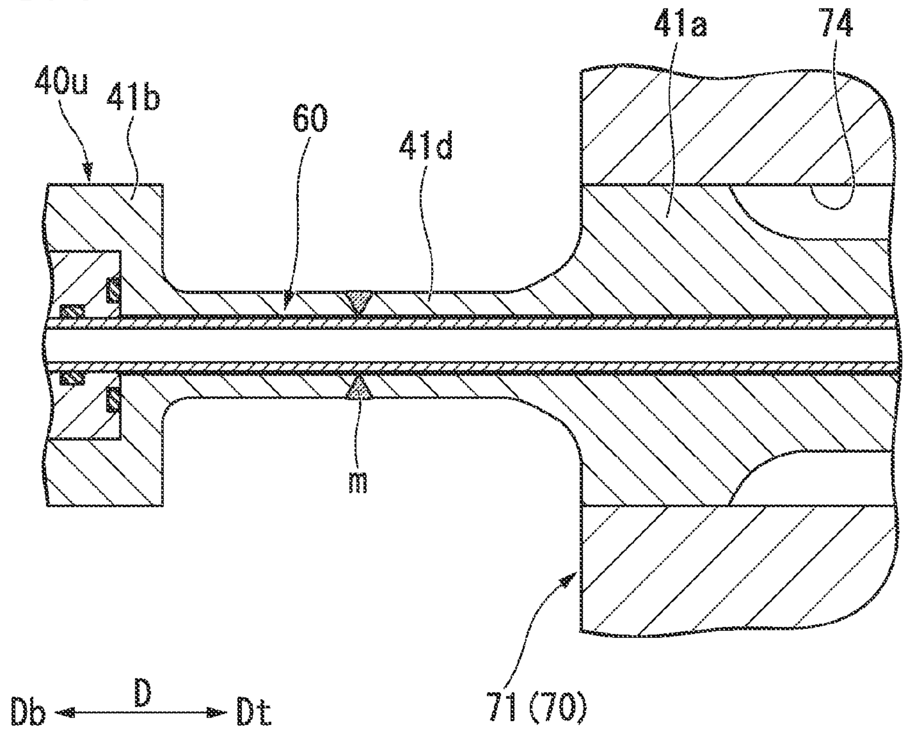
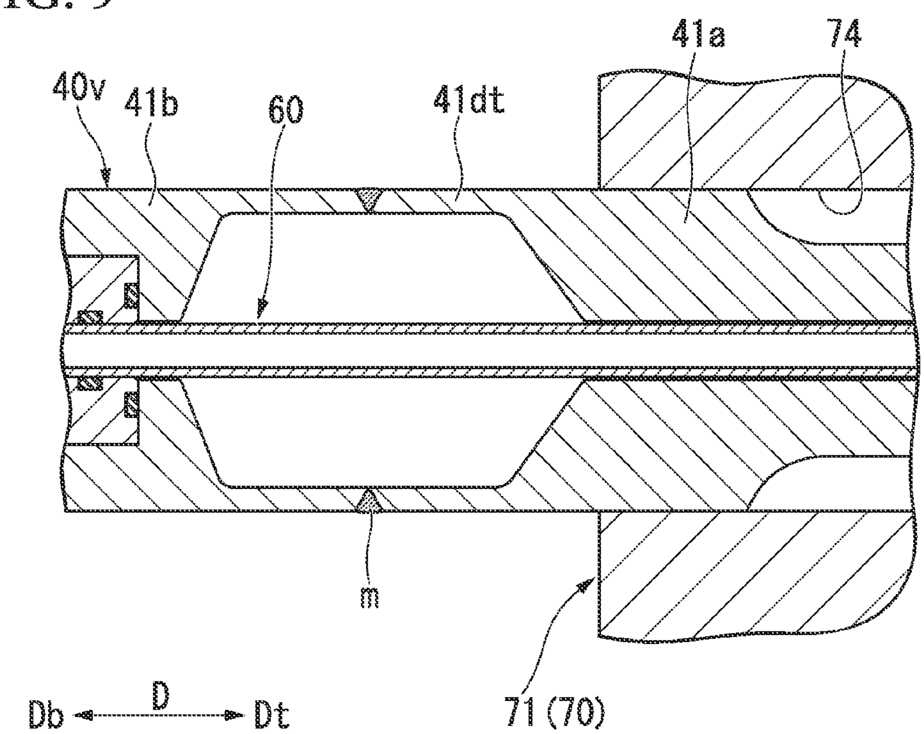

41a
74
40u
41b
60
41d
m
71(70)
Db
D
Dt

FIG. 9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41dt
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71(70)
Db
D
Dt

COMBUSTOR NOZZLE ASSEMBLY, COMBUSTOR EQUIPPED WITH THE SAME, AND GAS TURBINE

TECHNICAL FIELD

The present invention relates to a combustor nozzle assembly that injects fuel, a combustor equipped with the combustor nozzle assembly, and a gas turbine. Priority is claimed on Japanese Patent Application No. 2012-168535 filed on Jul. 30, 2012, the contents of which are incorporated herein by reference.

BACKGROUND ART

A combustor of a gas turbine includes a nozzle assembly having a nozzle which injects fuel into compressed air from a compressor of the gas turbine, and a transition piece which leads high-temperature gas generated by mixing fuel injected from a nozzle with the compressed air and burning the mixture, to a turbine. Although the present invention is not limited to this, as the nozzle, there is a so-called dual nozzle which injects both fuel oil and fuel gas.

The dual nozzle has a double-pipe structure, as shown in FIG. **5** of, for example, Patent Document 1 below, and includes a tubular nozzle rod and a tubular oil fuel pipe which is disposed in the nozzle rod. In the nozzle rod, a gaseous fuel flow path, through which gaseous fuel passes, is formed in a portion further on the outer periphery side than a pipe insertion space in which the oil fuel pipe is inserted. Further, the nozzle rod is fixed to a nozzle mounting base which blocks a combustor insertion opening formed in a gas turbine casing. A pipe tip portion of the oil fuel pipe is fixed to a rod tip portion of the nozzle rod. A pipe base end portion of the oil fuel pipe protrudes from a rod base end portion of the nozzle rod and the nozzle mounting base and is inserted in an oil manifold fixed to the nozzle mounting base. Oil fuel is supplied into the oil manifold and flows in the oil fuel pipe from there.

When the oil fuel is injected from the dual nozzle and burned (an oil firing operation), the oil fuel pipe is cooled by the oil fuel which flows therein. On the other hand, since the nozzle rod is exposed to the flow of the compressed air from the compressor of the gas turbine, the nozzle rod is heated by the compressed air. For this reason, although the temperatures of the oil fuel pipe and the nozzle rod are uniform at the time of stopping of the gas turbine, during the oil firing operation of the gas turbine, the temperature of the nozzle rod becomes relatively high with respect to the temperature of the oil fuel pipe. Due to this difference in temperature, a difference in thermal expansion between the oil fuel pipe and the nozzle rod occurs.

Further, when gaseous fuel is injected from the dual nozzle and burned (a gas firing operation), the oil fuel pipe is not cooled by the oil fuel. For this reason, the oil fuel pipe has a temperature close to the temperature of the nozzle rod and becomes hotter than when the oil fuel is burned. However, the temperature of the oil fuel pipe does not rise as much as the temperature of the nozzle rod directly exposed to the flow of the compressed air. Accordingly, even during the gas firing operation of the gas turbine, a difference in temperatures between the oil fuel pipe and the nozzle rod occurs, and as a result, a difference in thermal expansion between the oil fuel pipe and the nozzle rod occurs.

In this manner, since a difference in thermal expansion between the oil fuel pipe and the nozzle rod occurs, although the pipe tip portion of the oil fuel pipe is fixed to the rod tip portion of the nozzle rod, the pipe base end portion of the oil fuel pipe is inserted in the oil manifold so as to be able to relatively move with respect to the oil manifold. An O-ring is disposed between the outer periphery of the pipe base end portion of the oil fuel pipe and the inner surface of the oil manifold in order to suppress leakage of the oil fuel from between them while allowing a difference in expansion of the oil fuel pipe.

Incidentally, in the dual nozzle described above, heat in the gas turbine casing is easily transmitted to the O-ring or a rod base end portion of an oil fuel rod through the nozzle mounting base and the oil manifold. For this reason, the O-ring sometimes gets damaged due to heat being applied in a short period of time.

Therefore, in Patent Document 1, as shown in FIGS. 2 and 3 of Patent Document 1, there is proposed a technique to insert the pipe base end portion of the oil fuel pipe into the oil manifold by separating the oil manifold from the nozzle mounting base and making the amount of protrusion of the oil fuel pipe from the nozzle mounting base large. In addition, in Patent Document 1, there is also proposed a technique to provide a leaked oil recovery chamber on the pipe tip portion side of the oil fuel pipe based on the O-ring in the oil manifold in order to prevent leakage of the oil fuel due to the damage to the O-ring.

PRIOR ART DOCUMENT

Patent Document

Patent Document 1: Japanese Unexamined Patent Application, First Publication No. 2008-190402

SUMMARY OF INVENTION

Problem to be Solved by the Invention

In the technique disclosed in Patent Document 1 above, since the amount of heat transferred to the O-ring is surely reduced, the O-ring can be prevented from being damaged in a short period of time. In addition, even if the O-ring is damaged, since the leaked oil recovery chamber is present, the oil fuel leaking outside can be prevented. However, in the technique disclosed in Patent Document 1 above, the leaked oil recovery chamber is provided, whereby a structure of the oil manifold becomes complicated, and in addition, a support which supports the oil manifold is separately required, and thus there is a problem in that the manufacturing cost increases.

The present invention has an object to provide a combustor nozzle assembly in which fuel leaking outside can be prevented even while reducing the manufacturing cost, a combustor equipped with the combustor nozzle assembly, and a gas turbine.

Means for Solving the Problems

According to a first aspect of the present invention, a combustor nozzle assembly includes: a nozzle mounting base which blocks a combustor insertion opening formed in a turbine casing; a nozzle rod which is formed in a tubular shape, passes through the nozzle mounting base, and has a rod tip portion protruding to the inside of the turbine casing and a rod base end portion protruding to the outside of the turbine casing; a fuel pipe which is formed in a tubular shape, which is as a whole inserted into the nozzle rod, which has a pipe tip portion fixed to the rod tip portion of the nozzle rod and a pipe base end portion inserted into the rod base end portion of the nozzle rod, in which fuel is supplied to the inside through the rod base end portion, and which injects the fuel from the pipe tip portion through the rod tip portion of the nozzle rod; and a seal member which is disposed in the rod base end portion of the nozzle rod and suppresses leakage of the fuel to the pipe tip portion side between the inner periphery side of the nozzle rod and the outer periphery side of the fuel pipe.

In the combustor nozzle assembly, since the seal member is disposed in the rod base end portion of the nozzle rod which protrudes to the outside of the turbine casing, heating of the seal member by heat from the nozzle mounting base or the like can be suppressed. Accordingly, in the combustor nozzle assembly, damage to the seal member due to heat can be suppressed.

In addition, in the combustor nozzle assembly, since the entire fuel pipe is inserted in the nozzle rod, even if the seal member which suppresses leakage of fuel to the pipe tip portion side between the inner periphery side of the nozzle rod and the outer periphery side of the fuel pipe is damaged, leakage of the fuel can be prevented because the fuel flows in between the inner peripheral surface of the nozzle rod and the outer peripheral surface of the fuel pipe. Accordingly, in the combustor nozzle assembly, since an oil manifold having a complicated shape, in which a leaked oil recovery chamber is formed, and a support thereof become unnecessary, the manufacturing cost can be reduced.

In the combustor nozzle assembly, the nozzle rod may have a mounting portion which is located in the nozzle mounting base, and a cross-sectional area reduced portion which is a portion between the mounting portion and the rod base end portion and in which a cross-sectional area in a cross section perpendicular to a direction in which the nozzle rod extends is smaller than the maximum cross-sectional area of the mounting portion.

Since the cross-sectional area reduced portion is interposed between the rod base end portion of the nozzle rod in the combustor nozzle assembly and the mounting portion which is located in the nozzle mounting base, the rod base end portion of the nozzle rod exists at a position relatively far from the nozzle mounting base. For this reason, heat that the rod base end portion of the nozzle rod receives from the nozzle mounting base can be reduced. Further, since the cross-sectional area of the cross-sectional area reduced portion of the nozzle rod is smaller than the maximum cross-sectional area of the mounting portion of the nozzle rod, thermal resistance in a heat transfer pathway from the nozzle mounting base or the like to the rod base end portion increases.

For this reason, in the combustor nozzle, damage to the seal member in the rod base end portion due to heat can be suppressed.

In the combustor nozzle assembly in which the nozzle rod has the cross-sectional area reduced portion, it is preferable that the cross-sectional area reduced portion of the nozzle rod be exposed to the outside of a combustor.

In the combustor nozzle assembly, since the cross-sectional area reduced portion between the mounting portion and the rod base end portion of the nozzle rod is exposed to the outside of the combustor, heat transmitted from the mounting portion to the cross-sectional area reduced portion can be released to the outside of the combustor. Accordingly, in the combustor nozzle assembly, heat which is transmitted from the cross-sectional area reduced portion to the rod base end portion can be reduced, and thus damage to the seal member due to a higher temperature can be suppressed.

Further, in either one of the combustor nozzle assemblies described above, the rod base end portion of the nozzle rod may be exposed to the outside of a combustor.

In the combustor nozzle assembly, heat transmitted to the rod base end portion can be released to the outside of the combustor. Accordingly, in the combustor nozzle assembly, heat which is transmitted from the rod base end portion to the seal member can be reduced, and thus damage to the seal member due to a higher temperature can be suppressed.

Further, either one of the combustor nozzle assemblies described above may further include a fuel receiving pipe which is connected to the rod base end portion of the nozzle rod and supplies the fuel into the fuel pipe through the rod base end portion.

In a case of supplying fuel into the fuel pipe through the rod base end portion of the nozzle rod, a method to cover the rod base end portion with a manifold for fuel supply and a method to provide a fuel receiving pipe, as in the combustor nozzle assembly described above, are conceivable. In the former method, since the rod base end portion is covered with the manifold for fuel supply, release of heat from the rod base end portion to the outside cannot be expected too much. On the other hand, in the latter method, since the rod base end portion is not covered with the manifold for fuel supply, release of heat from the rod base end portion to the outside can be expected.

Accordingly, in the combustor nozzle assembly, heat which is transmitted from the rod base end portion to the seal member can be reduced, and thus damage to the seal member due to a higher temperature can be suppressed.

According to a second aspect of the present invention, a combustor includes: either one of the combustor nozzle assemblies described above; and a transition piece which leads combustion gas generated by burning of fuel injected from the nozzle of the combustor nozzle assembly, to a turbine.

According to a third aspect of the present invention, a gas turbine includes: the combustor; a turbine rotor which is rotated by the combustion gas from the combustor; and the turbine casing which covers the turbine rotor and on which the combustor is mounted.

Effects of the Invention

In the present invention, even if an oil manifold having a complicated shape, in which a leaked oil recovery chamber is formed, is not provided, it is possible to prevent leakage of fuel. Further, since it is not necessary to provide a support, the manufacturing cost can be reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an overall side view, with a main section partially cut away, of a gas turbine according to an embodiment of the present invention.

FIG. **2** is a cross-sectional view of a surrounding of a combustor of the gas turbine according to an embodiment of the present invention.

FIG. **3** is a perspective view of a main section of a combustor nozzle assembly according to an embodiment of the present invention.

FIG. **4** is an overall cross-sectional view of a main nozzle according to an embodiment of the present invention.

FIG. **5** is a cross-sectional view of a base end portion of the main nozzle according to an embodiment of the present invention.

FIG. **6** is a cross-sectional view of a main section of a nozzle rod in a first modified example according to an embodiment of the present invention.

FIG. **7** is a cross-sectional view of a main section of a nozzle rod in a second modified example according to an embodiment of the present invention.

FIG. **8** is a cross-sectional view of a main section of a nozzle rod in a third modified example according to an embodiment of the present invention.

FIG. **9** is a cross-sectional view of a main section of a nozzle rod in a fourth modified example according to an embodiment of the present invention.

DESCRIPTION OF THE EMBODIMENTS

Hereinafter, an embodiment of a combustor nozzle assembly, a combustor equipped with the combustor nozzle assembly, and a gas turbine according to an embodiment of the present invention will be described in detail referring to the drawings.

The gas turbine according to this embodiment includes a compressor **1** which compresses external air, thereby generating compressed air, a plurality of combustors **2** which mixes fuel from a fuel supply source with the compressed air and burns the mixture, thereby generating combustion gas, and a turbine **3** which is driven by the combustion gas, as shown in FIG. **1**.

The turbine **3** includes a turbine casing **4** and a turbine rotor **5** which rotates in the turbine casing **4**. The turbine rotor **5** is connected to, for example, an electric generator (not shown) which generates electricity by rotation of the turbine rotor **5**. The plurality of combustors **2** are fixed to the turbine casing **4** at equal intervals with respect to each other in a circumferential direction with an axis of rotation Ar of the turbine rotor **5** as the center. The combustor **2** includes a transition piece **10** which sends high-temperature and high-pressure combustion gas to blades of the turbine rotor **5**, and a combustor nozzle assembly **20** which supplies the fuel and the compressed air into the transition piece **10**. In addition, in the following, the combustor nozzle assembly **20** is simply referred to as a nozzle assembly **20**.

The nozzle assembly **20** includes a pilot nozzle **21**, a plurality of main nozzles **31** which are disposed at equal intervals in the circumferential direction with the pilot nozzle **21** as the center, a nozzle mounting base **70** on which the pilot nozzle **21** and the plurality of main nozzles **31** are mounted, as shown in FIG. **2**.

A combustor insertion opening **4***a* is formed in the turbine casing **4**. The nozzle mounting base **70** blocks the combustor insertion opening **4***a*. The nozzle mounting base **70** has a nozzle stand **71** on which the pilot nozzle **21** and the plurality of main nozzles **31** are mounted, and a nozzle stand frame **75** to which the nozzle stand **71** is fixed. The nozzle stand frame **75** is fixed to the turbine casing **4** by bolts.

Both the pilot nozzle **21** and the main nozzle **31** are formed in a rod shape and directed in the same direction. Both the pilot nozzle **21** and the main nozzle **31** pass through the nozzle mounting base **70**. A tip portion **21***t* of the pilot nozzle **21** and a tip portion **31***t* of the main nozzle **31** protrude into the turbine casing **4**. Further, a base end portion **21***b* of the pilot nozzle **21** and a base end portion **31***b* of the main nozzle **31** protrude to the outside of the turbine casing **4**. In addition, in the following, a direction in which the pilot nozzle **21** and the main nozzle **31** extend is set to be a nozzle longitudinal direction D, a direction in which the tip portions **21***t* and **31***t* of the pilot nozzle **21** and the main nozzle **31** are directed, in the nozzle longitudinal direction D, is set to be a tip side Dt, and a direction in which the base end portions **21***b* and **31***b* of the pilot nozzle **21** and the main nozzle **31** are directed, in the nozzle longitudinal direction D, is set to be a base end side Db.

A P-oil fuel receiving pipe **81** which receives oil fuel Fpo and a P-gaseous fuel receiving pipe **82** which receives gaseous fuel Fpg are connected to the base end portion **21***b* of the pilot nozzle **21**. An oil fuel flow path (not shown) through which the oil fuel Fpo flows and a gaseous fuel flow path (not shown) through which the gaseous fuel Fpg flows are formed in the pilot nozzle **21**. Both the flow paths are opened at the tip portion **21***t* of the pilot nozzle **21** and the respective fuels Fpo and Fpg are injected from here.

The main nozzle **31** has a tubular nozzle rod **40**, and a tubular oil fuel pipe **60** which is as a whole inserted into the nozzle rod **40**. The nozzle rod **40** passes through the nozzle stand **71** of the nozzle mounting base **70**. A rod tip portion **41***t* of the nozzle rod **40** protrudes into the turbine casing **4** and also a rod base end portion **41***b* of the nozzle rod **40** protrudes to the outside of the turbine casing **4**. In the nozzle rod **40**, a mounting portion **41***a* which is located in the nozzle mounting base **70** is fixed to the nozzle stand **71** of the nozzle mounting base **70** by welding. In addition, since the entire oil fuel pipe **60** is inserted into the nozzle rod **40**, the rod tip portion **41***t* of the nozzle rod **40** forms the tip portion **31***t* of the main nozzle **31** and the rod base end portion **41***b* of the nozzle rod **40** forms the base end portion **31***b* of the main nozzle **31**.

An M-gaseous fuel receiving pipe **89** which receives gaseous fuel Fmg is connected to the outer periphery side of the nozzle stand **71**, as shown in FIG. **4**. In the inside of the nozzle stand **71**, an annular fuel flow path **72** through which the gaseous fuel Fmg from the M-gaseous fuel receiving pipe **89** flows is formed at a position further on the outer periphery side than the plurality of main nozzles **31**. In addition, a branched flow path **73** which branches toward each main nozzle **31** from the annular fuel flow path **72** and an in-stand fuel space **74** which leads the gaseous fuel Fmg from the branched flow path **73**, to the surroundings of the mounting portion **41***a* of the nozzle rod **40**, are formed in the nozzle stand **71**.

In the rod base end portion **41***b* of the nozzle rod **40**, when the rod base end portion **41***b* is viewed in a direction from the base end side Db to the tip side Dt, a base end portion inner space **42** having a cylindrical shape is formed. An M-oil fuel receiving pipe **85** which receives oil fuel Fmo and communicates with the base end portion inner space **42** is connected to the rod base end portion **41***b*. Further, a pipe insertion space **44** which extends from the base end portion inner space **42** to the rod tip portion **41***t* and in which the oil fuel pipe **60** is inserted is formed in the nozzle rod **40**. In addition, in the nozzle rod **40**, a gaseous fuel flow path **45** which extends from the mounting portion **41***a* of the nozzle rod **40** to the rod tip portion **41***t* of the nozzle rod **40** is formed at a position further on the outer periphery side than the pipe insertion space **44**. The gaseous fuel flow path **45** is opened at the mounting portion **41***a* and communicates with the in-stand fuel space **74**. Further, the gaseous fuel flow path **45** is opened at the rod tip portion **41***t* and this opening forms an injection port **46** for fuel.

A portion of the nozzle rod **40** between the rod base end portion **41***b* and the mounting portion **41***a* forms a cross-sectional area reduced portion **41***d* in which a cross-sectional area in a cross section perpendicular to the nozzle longitudinal direction D is smaller than the maximum cross-sectional area of the mounting portion **41***a*. In addition, the cross-sectional area of the cross-sectional area reduced portion **41***d* is smaller than the maximum cross-sectional area of the rod base end portion **41***b* in a cross section perpendicular to the nozzle longitudinal direction D.

A pipe tip portion **61***t* of the oil fuel pipe **60** is disposed in the pipe insertion space **44** of the nozzle rod **40** and fixed at the position of the rod tip portion **41***t* of the nozzle rod **40** by welding. Further, a pipe base end portion **61***b* of the oil fuel pipe **60** extends to the inside of the rod base end portion **41***b* of the nozzle rod **40**. An oil fuel flow path **62** which passes through from the base end side Db of the oil fuel pipe **60** to the tip side Dt is formed in the oil fuel pipe **60**. The oil fuel flow path **62** is opened at the pipe base end portion **61***b* and the pipe tip portion **61***t*. The oil fuel Fmo flows from an opening of the pipe base end portion **61***b* into the oil fuel flow path **62**, flows out from an opening of the pipe tip portion **61***t*, and is injected from the injection port **46** of the nozzle rod **40** to the outside of the main nozzle **31**.

The main nozzle **31** has, in addition to the nozzle rod **40** and the oil fuel pipe **60** described above, a columnar inner piece **32** which is accommodated in the columnar base end portion inner space **42** of the nozzle rod **40**, a plurality of O-rings **36** as seal members, and an elastic body **37** such as a disk spring, as shown in FIG. **5**. The main nozzle **31** further has a bolt **38** which presses the elastic body **37** while blocking an opening on the base end side Db of the rod base end portion **41***b* in the base end portion inner space **42**, and a packing **39** which seals the gap between a bolt head portion of the bolt **38** and the rod base end portion **41***b* of the nozzle rod **40**.

The inner piece **32** is accommodated in an area on the tip side Dt of the base end portion inner space **42** of the nozzle rod **40**. In the inner piece **32**, a pipe insertion space **33** in which the pipe base end portion **61***b* of the oil fuel pipe **60** is inserted, a communication path **34** which makes the oil fuel pipe **60** and the M-oil fuel receiving pipe **85** communicate with each other, and seal grooves **35**, in each of which each of the O-rings **36** is mounted, are formed. The communication path **34** also plays a role as an orifice which controls the flow rate of the oil fuel Fmo from the M-oil fuel receiving pipe **85**, thereby making the flow rate of the oil fuel Fmo which flows in the oil fuel pipe **60** to be a target flow rate.

As the seal grooves **35**, there are a first seal groove **35***a* which is formed in the outer peripheral surface of the columnar inner piece **32**, a second seal groove **35***b* which is formed in the end face on the tip side Dt of the inner piece **32**, and a third seal groove **35***c* which faces the pipe insertion space **33**. The each O-ring **36** is disposed in the seal groove **35**. O-rings **36***a* and **36***b* which are disposed in the first seal groove **35***a* and the second seal groove **35***b* serve to seal the gap between the outer surface of the inner piece **32** and the inner surface of the rod base end portion **41***b*. Further, an O-ring **36***c* which is disposed in the third seal groove **35***c* serves to seal the gap between the inner surface of the inner piece **32** and the outer surface of the oil fuel pipe **60** while allowing thermal expansion and contraction of the oil fuel pipe **60** in the nozzle longitudinal direction D in the pipe insertion space **33** of the inner piece **32**.

Further, the O-ring **36***a* disposed in the first seal groove **35***a* seals the gap between the outer surface of the inner piece **32** and the inner surface of the rod base end portion **41***b*, thereby suppressing leakage of the oil fuel Fmo from between these surfaces to the base end side Db. On the other hand, the O-ring **36***b* disposed in the second seal groove **35***b* and the O-ring **36***c* disposed in the third seal groove **35***c* seal the gap between the outer surface of the inner piece **32** and the inner surface of the rod base end portion **41***b* and the gap between the inner surface of the inner piece **32** and the outer surface of the oil fuel pipe **60**, thereby suppressing leakage of the oil fuel Fmo from between these surfaces to the tip side Dt.

The elastic body **37** is disposed in the base end portion inner space **42** further on the base end side Db than the inner piece **32** with an elasticity direction thereof directed in the nozzle longitudinal direction D. The elastic body **37** is pressed to the tip side Dt by the bolt **38** which blocks an opening of the rod base end portion **41***b*, as described above. For this reason, the inner piece **32** is biased to the tip side Dt in the base end portion inner space **42** by the elastic body **37**.

The M-oil fuel receiving pipe **85** which is connected to the nozzle rod **40** has a plurality of connecting pipes **86** which connects the rod base end portions **41***b* of the nozzle rods **40** of the plurality of main nozzles **31** to each other, and a main receiving pipe **87** which supplies the oil fuel Fmo to one of the connecting pipes **86**, as shown in FIG. **3**. The plurality of main nozzles **31** are disposed at equal intervals in the circumferential direction with the pilot nozzle **21** as the center, as described above. For this reason, the plurality of connecting pipes **86** which connects the rod base end portions **41***b* of the nozzle rods **40** of the plurality of main nozzles **31** to each other are arranged in the circumferential direction with the pilot nozzle **21** as the center.

During an oil firing operation of the gas turbine according to this embodiment, the oil fuel Fmo is supplied from the outside through the M-oil fuel receiving pipe **85** to the plurality of main nozzles **31**. The oil fuel Fmo flows in the base end portion inner space **42** of the nozzle rod **40** of the main nozzle **31**. The oil fuel Fmo flows in the oil fuel flow path **62** of the oil fuel pipe **60** inserted into the pipe insertion space **33** of the inner piece **32**, through the communication path **34** of the inner piece **32** disposed in the base end portion inner space **42**, and is injected from the injection port **46** of the nozzle rod **40** to the outside of the main nozzle **31**. The oil fuel Fmo injected to the outside of the main nozzle **31** is mixed and burned with the compressed air from the compressor **1**. The high-temperature and high-pressure combustion gas generated by this burning is led to the blades of the turbine rotor **5** by the transition piece **10**.

The oil fuel pipe **60** is cooled by the oil fuel flowing in the oil fuel pipe **60**. On the other hand, since the nozzle rod **40** is exposed to the flow of the high-temperature and high-pressure compressed air from the compressor **1**, the nozzle rod **40** is heated by this compressed air. For this reason, although the temperatures of the oil fuel pipe **60** and the nozzle rod **40** are uniform at the time of stopping of the gas turbine, during the oil firing operation, the temperature of the nozzle rod **40** becomes relatively high with respect to the temperature of the oil fuel pipe **60**. Due to this temperature difference, a difference in thermal expansion between the oil fuel pipe **60** and the nozzle rod **40** occurs.

During a gas firing operation of the gas turbine according to this embodiment, the gaseous fuel Fmg is supplied to the plurality of main nozzles **31** through the M-gaseous fuel receiving pipe **89**. The gaseous fuel Fmg flows from the M-gaseous fuel receiving pipe **89** into the annular fuel flow path **72** in the nozzle stand **71** and flows from there through the branched flow path **73** and the in-stand fuel space **74** in the nozzle stand **71** into the gaseous fuel flow path **45** in the nozzle rod **40**.

The gaseous fuel Fmg is injected from the injection port **46** of the nozzle rod **40** to the outside of the main nozzle **31**.

The gaseous fuel Fmg injected to the outside of the main nozzle **31** is mixed and burned with the compressed air from the compressor **1**, similar to the time of the oil firing operation. The high-temperature and high-pressure combustion gas generated by this burning is led to the blades of the turbine rotor **5** by the transition piece **10**.

During this gas firing operation, since the oil fuel Fmo is not supplied to the oil fuel pipe **60**, the oil fuel pipe **60** is not cooled by the oil fuel Fmo. For this reason, the oil fuel pipe **60** has a temperature close to the temperature of the nozzle rod **40** and becomes hotter than when the oil fuel is burned. However, the temperature of the oil fuel pipe **60** does not rise as much as the temperature of the nozzle rod **40** directly exposed to the flow of the compressed air. Accordingly, even during the gas firing operation and the oil firing operation, a difference in temperatures between the oil fuel pipe **60** and the nozzle rod **40** occurs, and due to this, a difference in thermal expansion between the oil fuel pipe **60** and the nozzle rod **40** occurs.

Incidentally, the pipe tip portion **61***t* of the oil fuel pipe **60** is fixed to the rod tip portion **41***t* of the nozzle rod **40** by welding, as described above. For this reason, if the length of the oil fuel pipe **60** relatively changes with respect to the length of the nozzle rod **40**, the relative position of the pipe base end portion **61***b* of the oil fuel pipe **60** changes with respect to the position of the rod base end portion **41***b* of the nozzle rod **40**. Specifically, since, for example, compared to the time of stopping of the gas turbine, the temperature of the oil fuel pipe **60** during the oil firing operation is relatively lowered with respect to the temperature of the nozzle rod **40**, the length of the oil fuel pipe **60** with respect to the length of the nozzle rod **40** becomes relatively short. Accordingly, during the oil firing operation, compared to the time of stopping of the gas turbine, the position of the pipe base end portion **61***b* of the oil fuel pipe **60** moves to the tip side Dt with respect to the position of the rod base end portion **41***b* of the nozzle rod **40**.

In this manner, according to an operating condition of the gas turbine, in the nozzle longitudinal direction D, the position of the pipe base end portion **61***b* of the oil fuel pipe **60** relatively moves with respect to the position of the rod base end portion **41***b* of the nozzle rod **40**. For this reason, the O-ring **36***c* which is disposed in the third seal groove **35***c* of the inner piece **32** disposed in the rod base end portion **41***b* of the nozzle rod **40** allows thermal expansion and contraction of the oil fuel pipe **60** in the nozzle longitudinal direction D in the pipe insertion space **33** of the inner piece **32** even while sealing the gap between the inner surface of the inner piece **32** and the outer surface of the oil fuel pipe **60**.

Further, the inner piece **32** in the rod base end portion **41***b* of the nozzle rod **40** tends to move in the same direction as the moving direction of the pipe base end portion **61***b* due to the movement of the pipe base end portion **61***b* of the oil fuel pipe **60**. In addition, a difference in thermal expansion also occurs between the rod base end portion **41***b* of the nozzle rod **40** and the inner piece **32**. Due to this difference in thermal expansion, the inner piece **32** tends to move in the rod base end portion **41***b* of the nozzle rod **40**. For this reason, the O-rings **36***a* and **36***b* which are disposed in the first and second seal grooves **35***a* and **35***b* of the inner piece **32** disposed in the rod base end portion **41***b* of the nozzle rod **40** allows movement in the nozzle longitudinal direction D of the inner piece **32** in the rod base end portion **41***b* of the nozzle rod **40** even while sealing the gap between the outer surface of the inner piece **32** and the inner surface of the rod base end portion **41***b*.

Incidentally, the rod base end portion **41***b* of the nozzle rod **40** is provided to protrude to the outside of the turbine casing **4**. For this reason, it is difficult for the rod base end portion **41***b* of the nozzle rod **40** to receive heat from the nozzle mounting base **70**. Further, in the cross-sectional area reduced portion **41***d* of the nozzle rod **40**, as described above, the cross-sectional area in a cross section perpendicular to the nozzle longitudinal direction D is smaller than the maximum cross-sectional area in the mounting portion **41***a* of the nozzle rod **40**. For this reason, the cross-sectional area reduced portion **41***d* of the nozzle rod **40** increases thermal resistance in a heat transfer pathway from the turbine casing **4** to the rod base end portion **41***b*. In addition, since the rod base end portion **41***b* of the nozzle rod **40** is exposed to the outside of the combustor **2**, a cooling effect by heat exchange with the outside can also be expected. Accordingly, in this embodiment, an increase in the temperature of the rod base end portion **41***b* of the nozzle rod **40** according to combustion of the fuel and an increase in the temperature of the O-ring **36** according to the increase in the temperature of the rod base end portion **41***b* can be suppressed.

Therefore, according to this embodiment, damage to the O-ring **36** due to heat can be suppressed, and thus the life of the O-ring **36** can be extended.

Further, in this embodiment, even if the O-rings **36***b* and **36***c* which prevent leakage of the oil fuel Fmo to the tip side Dt are damaged, leakage of the oil fuel Fmo to the outside can be prevented. This is because the oil fuel Fmo which has flowed in the base end portion inner space **42** of the nozzle rod **40** flows in a heat insulating space between the inner surface of the nozzle rod **40** and the outer surface of the oil fuel pipe **60** through the gap between the inner surface of the inner piece **32** and the outer surface of the oil fuel pipe **60** sealed by the O-ring **36***c* or the gap between the outer surface of the inner piece **32** and the inner surface of the rod base end portion **41***b* of the nozzle rod **40** sealed by the O-ring **36***b*. That is, in this embodiment, the heat insulating space plays a role as a leaked oil recovery space at the time of damage to the O-rings **36***b* and **36***c*.

Further, in this embodiment, even if the O-ring **36***a* which prevents leakage of the oil fuel Fmo to the base end side Db is damaged, since the packing **39** exists further to the base end side Db than the O-ring **36***a*, leakage of the oil fuel Fmo to the outside can be prevented. Here, since the packing **39** is for sealing the gap between the bolt head portion of the bolt **38** and the rod base end portion **41***b* of the nozzle rod **40** which make little relative movement due to a change in temperature, the life of the packing **39** is longer than that of the O-ring **36***a*. For this reason, leakage of the oil fuel Fmo to the outside due to damage to the packing **39** need not be considered as much as damage to the O-ring **36**.

Therefore, in this embodiment, since an oil manifold having a complicated shape, in which a leaked oil recovery chamber is formed, and a support thereof become unnecessary, the manufacturing cost can be reduced.

Next, various modified examples of the nozzle rod will be described using FIGS. **6** to **9**.

First, a first modified example of the nozzle rod will be described using FIG. **6**.

The shape of a nozzle rod **40***s* according to this modified example is slightly different from the shape of the nozzle rod **40** in the above-described embodiment.

In the nozzle rod **40***s* according to this modified example, a mounting portion **41***as* which is located in the nozzle mounting base **70** has a main mounting portion **41***ax* in which a cross-sectional area in a cross section perpendicular to the nozzle longitudinal direction D is the largest, and a reduced diameter portion **41***ay*. The reduced diameter portion **41***ay* is formed on the base end side Db of the main mounting portion **41***ax* and the cross-sectional area of the reduced diameter portion **41***ay* is the same as the cross-sectional area of the cross-sectional area reduced portion **41***d* of the nozzle rod **40***s*.

In this manner, even if the mounting portion **41***as* of the nozzle rod **40***s* has the reduced diameter portion **41***ay*, if the cross-sectional area in a cross section perpendicular to the nozzle longitudinal direction D of the cross-sectional area reduced portion **41***d* is smaller than the maximum cross-sectional area of the mounting portion **41***as*, thermal resistance in the heat transfer pathway from the turbine casing **4** to the rod base end portion **41***b* can be increased, similar to the above-described embodiment.

Next, a second modified example of the nozzle rod will be described using FIG. **7**.

The shape of a nozzle rod **40***t* according to this modified example is also slightly different from the shape of the nozzle rod **40** in the above-described embodiment.

The outer diameter of a cross-sectional area reduced portion **41***dt* in the nozzle rod **40***t* according to this modified example is the same as the outer diameter of the mounting portion **41***a* and the inner diameter of the cross-sectional area reduced portion **41***dt* is larger than the inner diameter of the mounting portion **41***a*. For this reason, in the cross-sectional area reduced portion **41***dt*, the outer diameter of the cross-sectional area reduced portion **41***dt* becomes larger than the outer diameter of the cross-sectional area reduced portion **41***d* in the above-described embodiment. However, the cross-sectional area in a cross section perpendicular to the nozzle longitudinal direction D becomes smaller than the maximum cross-sectional area of the mounting portion **41***a* of the nozzle rod **40***t*, similar to the above-described embodiment. For this reason, also in this modified example, similar to the above-described embodiment, thermal resistance in the heat transfer pathway from the turbine casing **4** to the rod base end portion **41***b* can be increased.

Next, a third modified example of the nozzle rod will be described using FIG. **8**, and a fourth modified example of the nozzle rod will be described using FIG. **9**.

A nozzle rod **40***u* according to the third modified example has the same shape as the nozzle rod **40** in the above-described embodiment. However, the nozzle rod **40***u* according to this modified example is formed by joining a member on the tip side Dt of the nozzle rod **40***u* and a member on the base end side Db of the nozzle rod **40***u* to each other by welding. Further, a nozzle rod **40***v* according to the fourth modified example has the same shape as the nozzle rod **40***t* according to the second modified example. However, the nozzle rod **40***v* according to this modified example is also formed by joining a member on the tip side Dt of the nozzle rod **40***v* and a member on the base end side Db of the nozzle rod **40***v* to each other by welding, similar to the third modified example. For this reason, in the nozzle rods **40***u* and **40***v* according to these modified examples, welded portions m exists in, for example, the cross-sectional area reduced portions **41***d* and **41***dt*.

As in the nozzle rods **40***v* and **40***u* according to the third and fourth modified examples described above, even if the nozzle rod is formed by joining a member on the tip side Dt of the nozzle rod and a member on the base end side Db of the nozzle rod to each other by welding, basically the same effect as the nozzle rod **40** in the above-described embodiment or the nozzle rod **40***t* in the second modified example can be obtained. Further, in the nozzle rods **40***v* and **40***u* according to the third and fourth modified examples, if the welded portions m exist in the cross-sectional area reduced portions **41***d* and **41***dt*, thermal resistance in the heat transfer pathway from the turbine casing **4** to the rod base end portion **41***b* can be further increased.

In addition, here, each of the nozzle rods **40***v* and **40***u* having the same shape as the nozzle rod **40** in the above-described embodiment or the nozzle rod **40***t* in the second modified example is formed by joining of two members by welding. However, a nozzle rod having the same shape as the nozzle rod **40***s* according to the first modified example may also be formed by joining of two members by welding. In addition, here, the nozzle rod is formed by joining two members by welding. However, an oil fuel pipe having the same shape as the oil fuel pipe **60** in the above-described embodiment may also be formed by joining two members by welding.

Further, in the above-described embodiment, for flow rate regulation or the like, the inner piece **32** is disposed in the base end portion inner space **42** of the nozzle rod **40**. However, the inner piece **32** may be omitted. In this case, a function to regulate the flow rate of the oil fuel Fmo is given to a portion which receives the oil fuel Fmo from the M-oil fuel receiving pipe **85**, in the base end portion inner space **42**.

In addition, the main nozzle **31** in the above-described embodiment is a so-called dual nozzle which injects both fuel oil and fuel gas. However, the invention is not limited thereto, and if a nozzle has a nozzle rod and an oil fuel pipe, a nozzle which does not inject fuel gas is also acceptable.

INDUSTRIAL APPLICABILITY

According to the combustor nozzle assembly, even if an oil manifold having a complicated shape, in which a leaked oil recovery chamber is formed, is not provided, it is possible to prevent leakage of fuel. Further, since it is also not necessary to provide a support, the manufacturing cost can be reduced.

REFERENCE SIGNS LIST

- **1**: compressor
- **2**: combustor
- **3**: turbine
- **4**: turbine casing
- **4***a*: combustor insertion opening
- **5**: turbine rotor
- **10**: transition piece
- **20**: nozzle assembly
- **21**: pilot nozzle
- **31**: main nozzle
- **32**: inner piece
- **33**: pipe insertion space
- **36**: O-ring (seal member)
- **37**: elastic body
- **38**: bolt
- **39**: packing
- **40**, **40***s*, **40***t*, **40***u*, **40***v*: nozzle rod
- **41***b*: rod base end portion
- **41***d*, **41***dt*: cross-sectional area reduced portion
- **41***a*: mounting portion
- **41***t*: rod tip portion
- **42**: base end portion inner space
- **44**: pipe insertion space
- **45**: gaseous fuel flow path
- **46**: injection port
- **60**: oil fuel pipe
- **61***b*: pipe base end portion
- **61***t*: pipe tip portion

62: oil fuel flow path
70: nozzle mounting base
71: nozzle stand
75: nozzle stand frame

The invention claimed is:

1. A combustor nozzle assembly of a gas turbine comprising:

a nozzle mounting base that blocks a combustor insertion opening formed in a turbine casing;

a nozzle rod formed in a tubular shape, passes through the nozzle mounting base, and having a rod tip portion protruding to an inside of the turbine casing and a rod base end portion protruding to the outside of the turbine casing;

a fuel pipe formed in a tubular shape, inserted as a whole into the nozzle rod, having a pipe tip portion fixed to the rod tip portion of the nozzle rod and a pipe base end portion inserted into the rod base end portion of the nozzle rod, wherein fuel is supplied to an inside of the fuel pipe through the rod base end portion, and injects the fuel from the pipe tip portion through the rod tip portion of the nozzle rod; and

a seal member disposed in the rod base end portion of the nozzle rod and suppresses leakage of the fuel to a pipe tip portion side between an inner periphery side of the nozzle rod and an outer periphery side of the fuel pipe,

wherein the nozzle rod comprises:

a mounting portion located in the nozzle mounting base; and

a cross-sectional area reduced portion provided between the mounting portion and the rod base end portion, wherein a cross-sectional area of the cross-sectional area reduced portion perpendicular to a direction that the nozzle rod extends is smaller than a maximum cross-sectional area of the mounting portion, and is also smaller than a cross-sectional area of the rod base end portion.

2. The combustor nozzle assembly of a gas turbine according to claim **1**, wherein the cross-sectional area reduced portion of the nozzle rod is exposed to the outside of a combustor.

3. The combustor nozzle assembly of a gas turbine according to claim **1**, wherein the rod base end portion of the nozzle rod is exposed to the outside of a combustor.

4. The combustor nozzle assembly of a gas turbine according to claim **1**, further comprising:

a fuel receiving pipe connected to the rod base end portion of the nozzle rod and supplies the fuel into the fuel pipe through the rod base end portion.

5. A combustor of a gas turbine comprising:

the combustor nozzle assembly of a gas turbine according to claim **1**; and

a transition piece that leads combustion gas generated by burning of fuel injected from the pipe tip portion of the nozzle rod of the combustor nozzle assembly, to a turbine.

6. A gas turbine comprising:

the combustor according to claim **5**;

a turbine rotor that is rotated by the combustion gas from the combustor; and

the turbine casing that covers the turbine rotor and wherein the combustor is mounted to the turbine casing.

* * * * *